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Digital Mapping and Environmental Characterization of the National Wild and Scenic Rivers System

September 2013

Prepared by

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Environmental Sciences Division

DIGITAL MAPPING AND ENVIRONMENTAL CHARACTERIZATION OF NATIONAL WILD AND SCENIC RIVER SYSTEMS

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ABBREVIATIONS, ACRONYMS, AND INITIALISMS

BLM	Bureau of Land Management
EA	Environmental Attribution
FWS	US Fish and Wildlife Service
GIS	Geospatial Information System
HEM	Hydrography Event Management Tool
NHAAP	National Hydropower Asset Assessment Program
NHD	National Hydrography Dataset
NPS	National Park Service
NWSRS	National Wild and Scenic Rivers System
ORNL	Oak Ridge National Laboratory
PLSS	Public Land Survey System
USFS	US Forest Service
USGS	US Geological Survey
WSR	Wild and Scenic River
WSRA	Wild and Scenic River Act
WSR-HYD	WSRs digitized using USGS hydrography (1:2M scale).
WSR-NHD	WSRs digitized at the NHD high resolution (1:24k scale)

ABSTRACT

Spatially accurate geospatial information is required to support decision-making regarding sustainable future hydropower development. Under a memorandum of understanding among several federal agencies, a pilot study was conducted to map a subset of National Wild and Scenic Rivers (WSRs) at a higher resolution and provide a consistent methodology for mapping WSRs across the United States and across agency jurisdictions. A subset of rivers (segments falling under the jurisdiction of the National Park Service) were mapped at a high resolution using the National Hydrography Dataset (NHD). The spatial extent and representation of river segments mapped at NHD scale were compared with the prevailing geospatial coverage mapped at a coarser scale. Accurately digitized river segments were linked to environmental attribution datasets housed within the Oak Ridge National Laboratory's National Hydropower Asset Assessment Program database to characterize the environmental context of WSR segments. The results suggest that both the spatial scale of hydrography datasets and the adherence to written policy descriptions are critical to accurately mapping WSRs. The environmental characterization provided information to deduce generalized trends in either the uniqueness or the commonness of environmental variables associated with WSRs. Although WSRs occur in a wide range of human-modified landscapes, environmental data layers suggest that they provide habitats important to terrestrial and aquatic organisms and recreation important to humans. Ultimately, the research findings herein suggest that there is a need for accurate, consistent, mapping of the National WSRs across the agencies responsible for administering each river. Geospatial applications examining potential landscape and energy development require accurate sources of information, such as data layers that portray realistic spatial representations.

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1. INTRODUCTION

The Wild and Scenic River Act (WSRA) was established by Congress in 1968 to preserve certain rivers across the United States with outstanding and remarkable natural, cultural, or aesthetic qualities for the enjoyment of present and future generations (NWSRS 2013). Currently the WSRA protects 12,598 miles of 203 rivers in the continental United States and Puerto Rico (NWSRS 2013) (Fig. 1). Section 1b of the WSRA states:

> *It is hereby declared to be the policy of the United States that certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations. The Congress declares that the established national policy of dams and other construction at appropriate sections of the rivers of the United States needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the water quality of such rivers and to fulfill other vital national conservation purposes.* (Wild & Scenic Rivers Act, October 2, 1968)

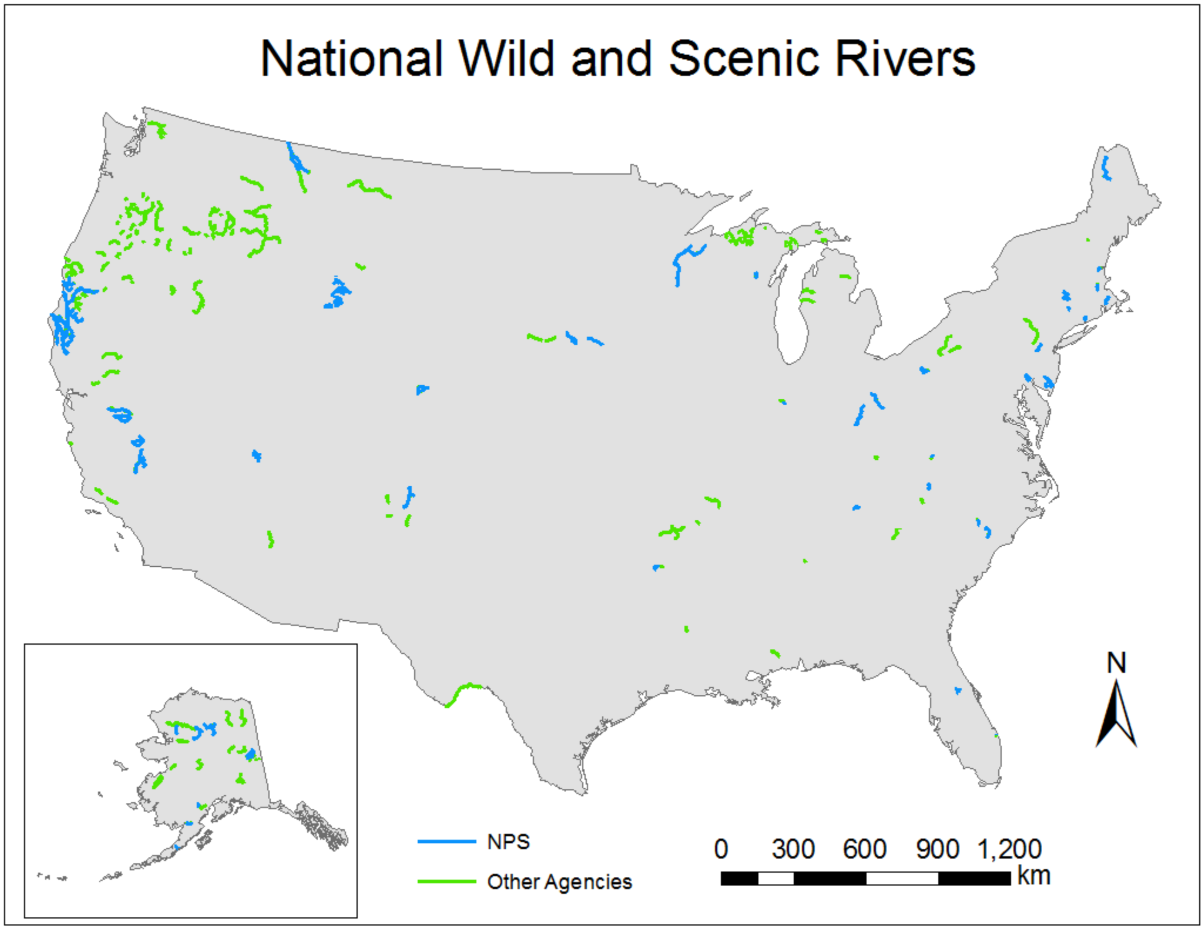

Fig. 1. WSRs falling under full or partial National Park Service jurisdiction and that of other agencies.

By definition, for a river to be considered and designated as “wild and scenic,” it must be free flowing and possess one or more outstanding remarkable values referred to in Section 1b of the WSRA. The WSRA was designed to balance dam and river infrastructure development in appropriate river systems with providing protection for river systems with outstanding qualities (NWSRS 2013). To maintain free flowing status, the construction of dams is prohibited. However, other structures such as bridges and docks can be evaluated by the managing agency (Section 7). Wild and Scenic River (WSR) designation neither prohibits landscape development nor gives the federal government control over private property, existing water rights, and established jurisdictions (WSRA 1968; NWSRS 2013). The WSR designation boundary is typically limited to 320 acres per mile of river (roughly 0.25 miles on either side of the river) with different standards for Alaska (Section 6 and 15, WSRA 1968). The WSRA allows the Secretary of the Interior or Secretary of Agriculture to acquire lands from willing sellers. With many of the WSRs, the land adjacent to the boundaries is not completely public (NWSRS 2013).

The US Forest Service (USFS), Bureau of Land Management (BLM), US Fish and Wildlife Service (FWS), and National Park Service (NPS) are the four administering agencies presiding over WSRs. Administering agencies may individually or jointly preside over a given river system. The NPS has responsibilities for 58 rivers, 30 of which are adjacent to or fall within NPS lands, 11 of which are partnerships between NPS and states, and 17 of which are administered by states or tribes with NPS responsibility (NPS 2013) (Fig. 1). The USFS, BLM, and FWS have responsibilities for 121, 69, and 8 rivers respectively.

This report addresses a need to accurately digitize and map WSRs to provide more convenient and accurate public information. In addition, the report presents a consistent methodology that can be used uniformly across all four agencies with administration over WSRs. Section 3c of the WSRA specifically indicates that all maps and descriptions of boundaries of designated river segments should be provided for public inspection (WSRA 1968). Much of the official map information is available only in paper files. For most of the public, two sources of information are currently available on the spatial extent of WSRs: (1) written descriptions of the upstream and downstream bounds of each river system designated within the WSRA and (2) map images and geospatial coverage of stream network vectors provided online by the National Wild and Scenic River System (NWSRS) (NWSRS 2013).

1.1 THE NEED TO ACCURATELY MAP NATIONAL WILD AND SCENIC RIVERS

The physical locations of WSRs—boundaries, coordinates, and landmarks—are typically supported by written descriptions within Section 3c of the WSRA. In the course of designating many WSRs, it is presumed that topographic maps and imagery were used to assign the upstream and downstream bounds of each river system, as well as the acreage of land boundary adjacent to the high-water mark of each river system. Digital maps of WSRs are needed to support a wide array of landscape-type analyses regarding direct overlap or potential impact of development. Thus remote sensing and geospatial information systems (GIS) are required to create or digitize WSRs to provide an accurate representation for public use. The most comprehensive digitized version of the WSRs was compiled by many individuals within the US Geological Survey (USGS) National Atlas and the Interagency Wild and Scenic River Coordinating Council (NWSRS 2013). These GIS data and maps are provided by the NWSRS and only include river segment data and not information on boundaries and land ownership (NWSRS 2013).

Within the existing GIS coverage, data for most WSRs were collected before 2000 using the USGS 2 million-scale streams and waterbodies data layer (NWSRS 2013), which is provided by National Atlas (2013). On a 1:2 million (1:2M) scale map, 1 inch equals 31.6 miles on the land surface (National Atlas 2013). Thus the spatial representation of streams and waterbodies in the USGS data set is fairly coarse and many small features, such as tributaries and stream undulations, cannot be portrayed at this scale (National Atlas 2013). Some of the more recently designated WSRs, however, were digitized at a

1:24,000 (1:24k) scale, which provides a finer-resolution spatial representation (NWSRS 2013). Because of the coarse resolution of the original GIS layer, more accurate coverage would enhance the digital mapping and geospatial representations of the WSRs.

Another potential inaccuracy in mapping WSRs is the interpretation of legislative descriptions defining the upstream and downstream bounds of each river segment. Many of the delineations within Section 3c of WSRA provide adequate descriptions. For example, for the Cache la Poudre River segment in Colorado, the description for the delineation of the river segments reads as follows:

> *From Poudre Lake downstream to where the river intersects the easterly north-south line of west ½ SW ¼ of section 1, T8N, R71W of the sixth principal meridian. The South Fork from its source to section 1, T7N, R73W of the sixth principal meridian; from its intersection with the easterly section line of section 30, T8N, R72W of the sixth principal meridian to the confluence with the main stem.* (October 2, 1968, WSRA, http://www.rivers.gov/rivers/cache-la-poudre.php).

From that description, although it is obscure to many people, the exact point locations of the upstream and downstream extent can be accurately determined using a Public Land Survey System (PLSS) or a topographic map. However, there are many examples of poor delineations that require interpretation. For example, the description for the Wolf River in Wisconsin reads:

> *From the Langlade-Menominee County line downstream to Keshena Falls.* (October 2, 1968, WRSA 1968, http://www.rivers.gov/rivers/wolf.php)

The problem with this description is the interpretation of where the downstream end stops. "To Keshena Falls" can be interpreted as the upstream, middle, or downstream extent of the falls. Several segments of the Delaware River (Lower) in New Jersey and Pennsylvania have been designated. The description for the second segment is problematic as it reads:

> *…from just south of the Gilbert Generating Station to just north of the Point Pleasant Pumping Station.* (November 1, 2000, WSRA 1968-ammendments, http://www.rivers.gov/rivers/delaware-lower.php)

The issue of accuracy in digitizing the WSRS is compounded not only by interpretation and the coarseness of the 1:2M data set but also by the way the 1:2M data set is organized. Each digitized stream line vector in the 1:2M coverage is accompanied by a waterbody name. However, each digitized stream line may generalize multiple segments and incoming tributaries. Thus the naming convention of the coarse layer may be problematic in issues of interpretation and determining where to cut stream lines.

In 2000, the National Hydrography Dataset (NHD) high-resolution version was created to provide nationally comprehensive and highly accurate geospatial coverage of stream network vectors useful for mapping and spatial analysis (USGS 2013a). The NHD provides the most appropriate high-resolution mapping data source for national-scale stream network applications at a scale of 1:24k. Given the need for spatially accurate geospatial information to support decision-making regarding sustainable future development, higher-resolution mapping of the WSRs is needed. In addition, because four different federal agencies have independent and joint administrative duties over WSRs, there is a need for a consistent approach to mapping WSR river systems across agencies.

1.2 OBJECTIVES

The objectives of this report are two-fold. First, it presents a consistent methodology for mapping WSRs across the United States and across agency jurisdictions as to provide uniformity in mapping efforts, but also a more accurate representation for public use. For example, a subset of WSRs (segments falling under the jurisdiction of the NPS) are mapped at high resolution using NHD flowlines. The methodology description is followed by a brief discussion of results and of the implications of spatial representation and potential associated error on management decisions. Second, accurately digitized WSR segments are linked to the Oak Ridge National Laboratory (ORNL) National Hydropower Asset Assessment Program (NHAAP) environmental datasets to develop a database for characterizing the environmental context of WSR segments and support future queries. Describing environmental variables associated with WSR segments provides a broader understanding of how these river systems support policy.

2. MAPPING NATIONAL WILD AND SCENIC RIVERS

2.1 METHODS

2.1.1 Selection of a stream network framework

The high-resolution version of the NHD is the most comprehensive, consistent, accurate national stream network geospatial coverage available and provides a framework to support the digital mapping of WSRs. The digitized vector dataset represents natural and artificial hydrography features, such as lakes, streams, canals, and dams. NHD data can be used for data analysis that requires the ability to traverse dendritic stream networks. The high-resolution NHD was developed at a 1:24k scale, whereas the medium-resolution version was developed at a 1:100,000 scale (1:100k). Only local scale-resolution datasets (1:5,000), available only in limited areas, exceed the resolution of the high-resolution NHD.

2.1.2 Delineating the upstream and downstream boundaries of WSRs

Delineating upstream and downstream boundaries required locating points on a topographic map or PLSS map based on designated reach segments described in Section 3c of the WSRA. The purpose here is to accurately digitize WSRs at 1:24k; however, note that the BLM, USFS, and FWS may have more accurate geospatial information on upstream and downstream end points in the rivers they administer. Using a topographic base map in ArcMap, the upstream and downstream points were located using observation, measurement, and interpretation where appropriate. Once the correct points were determined, markers were placed to ensure accuracy during the digitization process.

2.1.3 Incorporating stream boundaries into NHD using the HEM tool

Once designated upstream and downstream points were determined, NHD flowline data and the USGS Hydrography Event Management tool (HEM) were used to digitize linear features of the designated WSRs. The HEM tool provides the capability for adding events (points, lines, polygons) to NHD flowlines while maintaining the full functionality (i.e., routing) of the NHD stream network (USGS 2013b). Events are specific locations along NHD flowlines that provide informational data, such as lakes or dams. Events provide a mechanism for linking large amounts of scientific information to the NHD while maintaining the feasibility of stream network design and advanced analyses, and thus establish upstream and downstream boundaries to NHD lines while maintaining stream network functionality.

All procedures were carried out in ArcGIS 10.1. New line events were created in ArcCatalog using the HEM toolbar. Line projections were set to Geographic Projection NAD83. (Note: Features must be created in the same projection as NHD data for HEM to work properly). Within ArcMap, the HEM toolbar was used to create new line events. Upstream and downstream points (based on boundaries delineated in the previous section) were used to locate the upstream and downstream extent of rivers on the NHD flowline. In addition, river names from NHD were used to search for mainstem and tributaries and for quality-control purposes. HEM then created a new line event feature containing NHD reach codes and permanent identifiers that could be used to link each new event to tabular information, such as administering agency or river name.

2.1.4 Comparison of new and old stream networks

WSRs digitized at the NHD high resolution (WSR-NHD, 1:24k scale) were compared with the existing WSR version digitized using USGS hydrography (WSR-HYD, 1:2M scale). Because different WSR sections may cross multiple state boundaries or fall under multiple agency jurisdictions, many WSR-HYD rivers were split into multiple reaches. Thus separate WSR-HYD reaches were consolidated into one river network polyline for each river and then sorted to select only rivers applicable to the current study. To ensure unbiased comparisons, WSR-HYD rivers were spatially joined (ArcGIS 9.3) to WSR-NHD rivers and each join was manually reviewed to ensure that both versions approximate the same river network area. The total mileage (US miles) for each WSR version was calculated using the USA Contiguous Albers Equal Area Conic USGS projection (ArcGIS 9.3). WSR-NHD was not compared with the WSR mileage table provided by NWSRS (NSWRS 2013) because no information was provided on how the data were compiled. Information sources such as the geospatial projection and the underlying stream network layer used to create the WSR mileage would be required to ensure an unbiased comparison. However, the mileage table is based on legislative descriptions and was likely developed without the use of sophisticated mapping techniques.

2.2 RESULTS

Forty-nine of the 203 WSRs were digitized according to NHD high-resolution lines. Total mileage across the 49 WSRs ranged from just under 9 river miles (Loxahatchee River, FL) to almost 480 (Eel River, CA). WSR-NHD versions typically had higher sinuosity than WSR-HYD versions (Fig. 2), which was expected because finer-resolution datasets (NHD) follow stream undulations more closely than coarser ones. Discrepancies in the two versions were sometimes large and varied. For example, stream lines in the WSR-HYD version of the Lumber River in North Carolina were up to 2,000 m removed from WSR-NHD lines in certain reaches (Fig. 2A and C). The WSR-HYD version of the Eel River in California was at least 500 m from the WSR-NHD version in certain reaches (Fig. 2B and D). In addition, the number of river tributaries in the WSR-NHD version varied significantly from that in the WSR-HYD version. For example, in the Charley River in Alaska, large stream tributaries included in WSR-HYD were excluded in WSR-NHD (Fig. 3). In the latter case, the discrepancy between the two WSR versions may not have been due to spatial resolution of stream network data. Rather, the inclusion or exclusion of specific tributaries within the WSR-NHD versions may be the result of careful attention to the actual reach boundaries outlined in the written policy designation. Mileage comparisons for the two versions also showed considerable differences (Table 1). With a few exceptions, WSR-NHD mileage exceeded WSR-HYD mileage, probably because of increased sinuosity in the WSR-NHD version. However, in some cases (e.g., the Klamath River California), WSR-HYD included more tributaries than were supported by policy descriptions. Total cumulative river mileage was 4949 for WSR-NHD and 4445 for WSR-HYD, a difference of 503 miles.

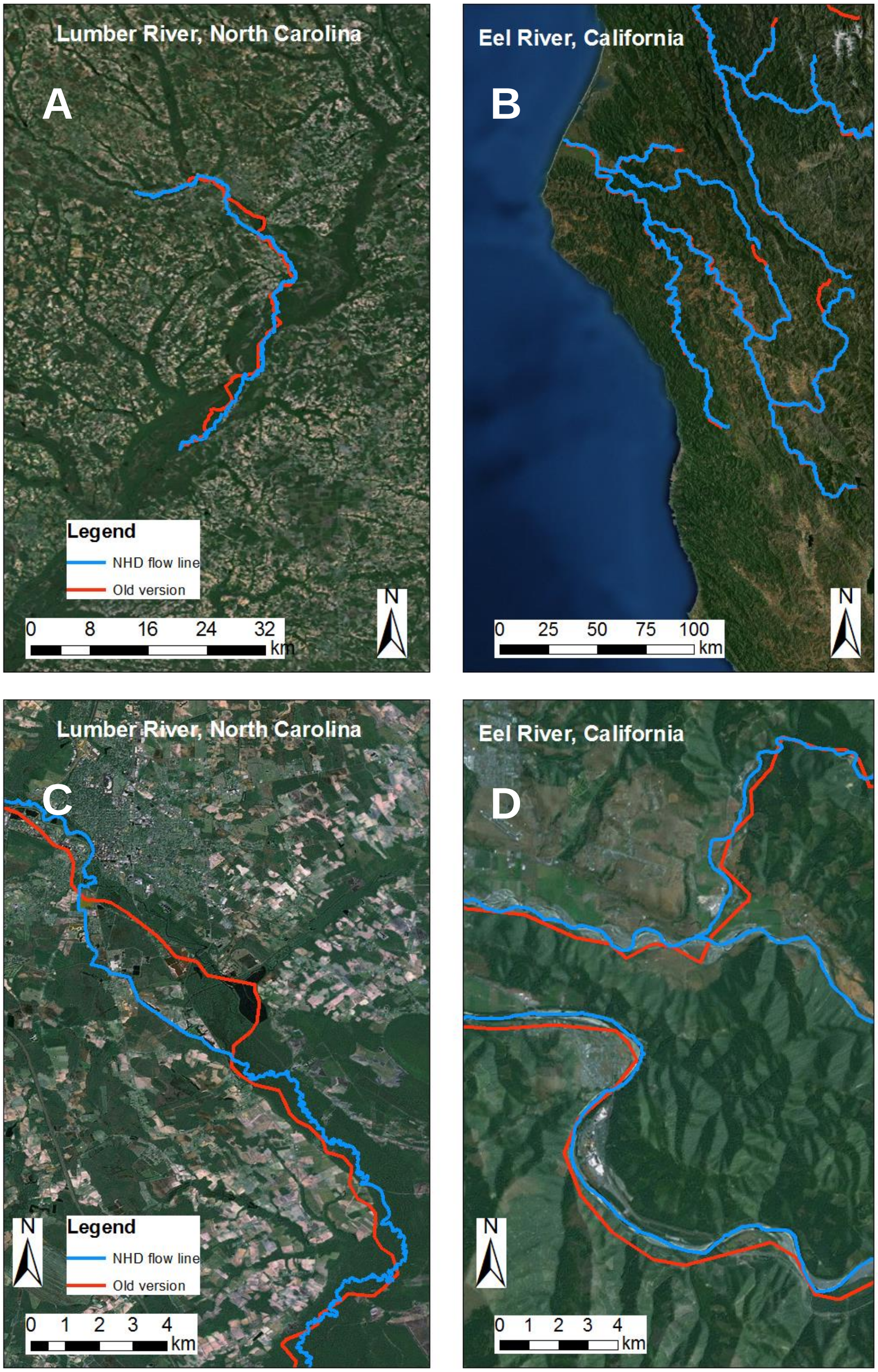

Fig. 2. Aerial views comparing NHD digitized version and USGS Hydrography (old version) for coarse and fine representations of the (A and C, respectively) Lumber Wild and Scenic River, North Carolina, and (B and D, respectively) Eel Wild and Scenic River California.

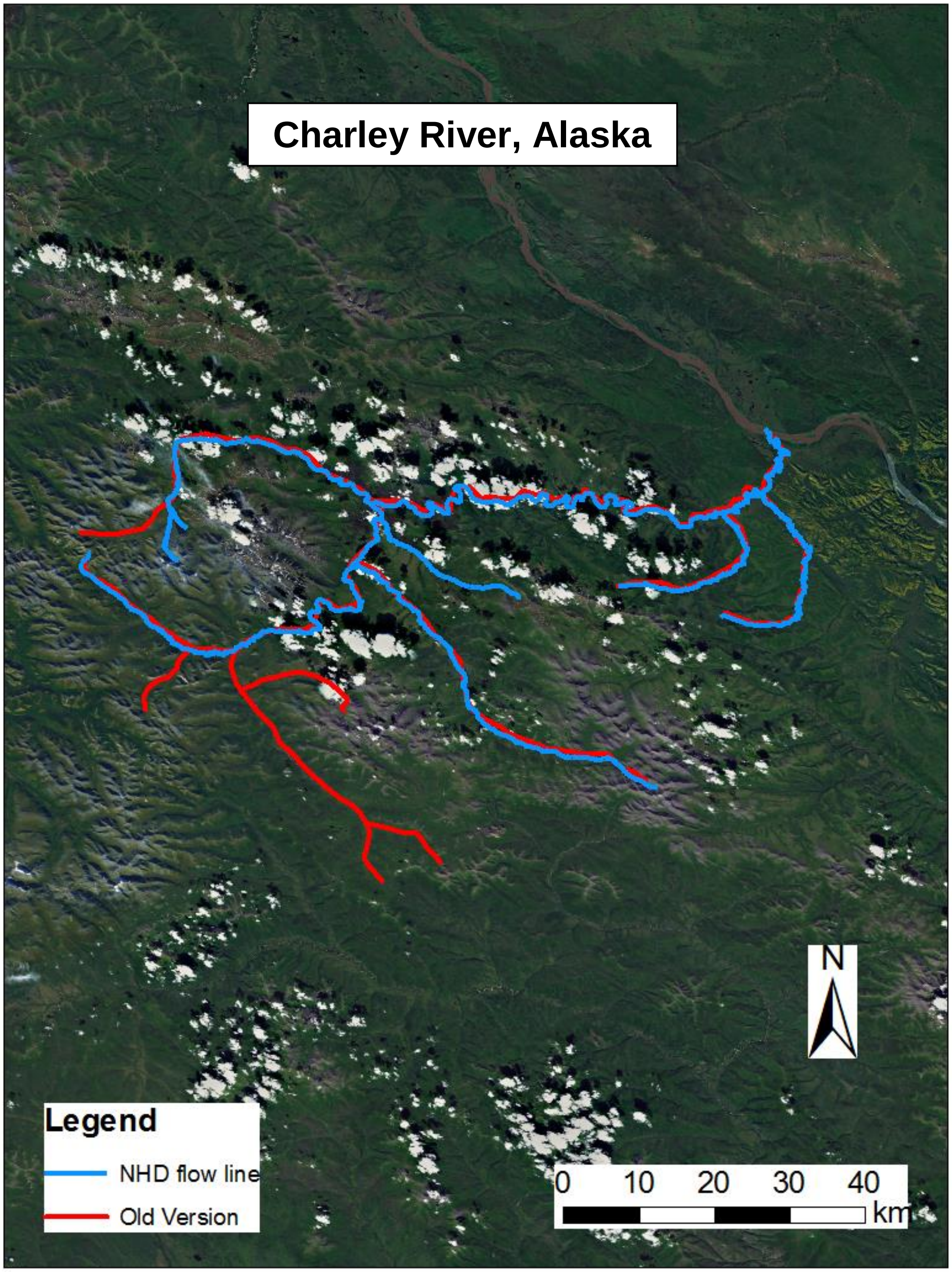

Fig. 3. Aerial view depicting WSR-NHD and WSR-HYD versions of the Charley WSR in Alaska.

Table 1. Comparison of river mileage (US miles) for WSRs digitized according to NHD reaches (WSR-NHD) and USGS Hydrography reaches (WSR-HYD)

WSID	River name	WSR-NHD mileage	WSR-HYD mileage	Difference
ALAG1	Alaganack River, AK	69.6	56.9	12.7
ALAT1	Alatna River, AK	92.2	70.1	22.0
ALLA1	Allagash River, ME	109.6	175.2	-65.6
ANIA1	Aniakchak River, AK	81.8	28.2	53.6
BLD1	Big and Little Darby Creeks, OH	82.8	69.2	13.7
BLSTN1	Bluestone River, WV	13.5	12.7	0.8
CLP1	Cache le Poudre River, CO	91.2	76.3	14.9
CHIL1	Chilikadrontna River, AK	21.3	16.9	4.4
CHAR1	Charley River, AK	251.9	227.4	24.4
CSL1	Cossalot River, AK	27.2	23.7	3.5
EEL1	Eel River, CA	479.2	364.0	115.3
8M1	Eight Mile River, CT	25.4	25.7	-0.2
FARM1	Farmington River, CT	13.9	12.7	1.2
FLTH1	Flathead River, MT	194.4	213.3	-19.0
GREG1	Great Egg Harbor River, NJ	77.8	60.9	16.9
JOHN1	John River, AK	67.0	53.1	13.9
KERN1	Kern River, CA	130.7	107.8	22.9
KING1	Kings River, CA	89.7	77.3	12.4
KLAM1	Klamath River, CA	193.6	287.0	-93.4
KOBU1	Kobuk River, AK	119.9	80.3	39.6
LAMP1	Lamprey River, NH	23.0	48.9	-25.9
LIBE1	Little Beaver River, OH	58.5	47.0	11.5
LIMI1	Little Miami River, OH	93.7	84.7	9.0
LOXA1	Loxahatchee River, FL	8.8	6.3	2.5
LUMB1	Lumber River, NC	78.8	56.0	22.7
MAUR1	Maurice River, NJ	27.0	19.4	7.6
MERC1	Merced River, CA	130.1	95.7	34.4
MISS1	Missouri River, NB & SD	122.3	94.0	28.3
MULC1	Mulchatna River, AK	25.4	NA	NA
MUSC1	Musconetcong River, NJ	25.5	28.4	-2.9
NR1	New River, NC	26.9	26.7	0.2
NFKO1	North Fork Koyuku River, AK	116.5	75.3	41.2
OB1	Obed River, TN	42.7	36.1	6.6
RIGR1	Rio Grande River, NM	82.8	55.6	27.1
SAC1	Sudbury/Assabet/Concord River, MA	30.7	29.7	1.0
SALM1	Salmon River, AK	77.4	48.2	29.2

Table 1. Comparison of river mileage (US miles) for WSRs digitized according to NHD reaches (WSR-NHD) and USGS Hydrography reaches (WSR-HYD) (continued)

WSID	River name	WSR-NHD mileage	WSR-HYD mileage	Difference
SMIT1	Smith River, CA	123.4	99.5	23.9
SNAK1	Snake River Headwaters, WY	407.8	410.6	-2.8
STCR1	St Croix River, MN & WI	256.1	223.1	33.0
TAUN1	Taunton River, MA	38.3	38.5	-0.2
TINA1	Tinayguk River, AK	54.5	46.2	8.4
TRIN1	Trinity River, CA	245.1	209.6	35.5
TUOL1	Tuolomne River, CA	76.1	82.7	-6.6
VERM1	Vermillion River, IL	16.7	26.2	-9.5
VIRG1	Virgin River, UT	162.6	172.5	-9.9
WEKI1	Wekiva River, FL	46.0	48.6	-2.6
WEST1	Westfield River, MA	84.1	83.9	0.2
WHIT1	White Clay Creek, DE & PA	211.5	193.3	18.2
WOLF1	Wolf River, WI	23.8	20.4	3.4
Total		**4949**	**4445**	**503**

3. CHARACTERIZING THE ENVIRONMENTAL CONTEXT OF WILD AND SCENIC RIVERS

The ORNL NHAAP database provides a wealth of information on geospatial environmental datasets related to aquatic ecosystems. Because these data layers are collated in a central depository, the process of building a geodatabase around WSRs can be expedited. Environmental data layers describing the ecological diversity, recreational opportunities, and land ownership can be used to describe the environmental context of WSRs. Many of the environmental data layers contained within the ORNL NHAAP database are provided online (ORNL 2013) and discussed in a methodology report (Hadjerioua et al. 2012).

3.1 METHODS

A database was constructed linking the WSR-NHD polygons to spatial coverages of environmental data. Figure 4 depicts the database. WSR-NHD polygons were joined to environmental data in various ways, depending on the scale at which the environmental information was summarized. For environmental data with spatial coverage not summarized within boundaries (e.g., watersheds), a 500 m buffer was created around WSR-NHD river segments and then spatially joined to each environmental layer (using identity function, ArcGIS 10.1, Fig. 4). The 500 m buffer is approximately equal to 0.25 mile, the maximum acreage allowed in the WSRA for the land boundary adjacent to each WSR (Section 3, WSRA 1968). Thus the acreage of protected lands and number of recreation points occurring near each WSR could be summarized. Protected lands refer to areas owned by public or private (e.g. easements) entities that are managed for conservation purposes with varying levels of protection (e.g. biodiversity protect to multiple extractive uses). For environmental data summarized within watersheds (e.g. HUC08 subbasins, HUC12 subwatersheds), WSR-NHD river segments were spatially joined to hydrologic unit code (HUC) watersheds. Afterward, tabular joins could relate multiple tables using common identifiers (e.g. HUC08 code). Because WSR-NHD segments were created at the 1:24k NHD scale, other datasets summarized at that scale (e.g. EPA 303d listed/impaired waterbodies) could simply be linked by the reach code identifier in a tabular join. Based on the creation of the database, a series of queries were developed to provide a general summary of the WSR-NHD polygons.

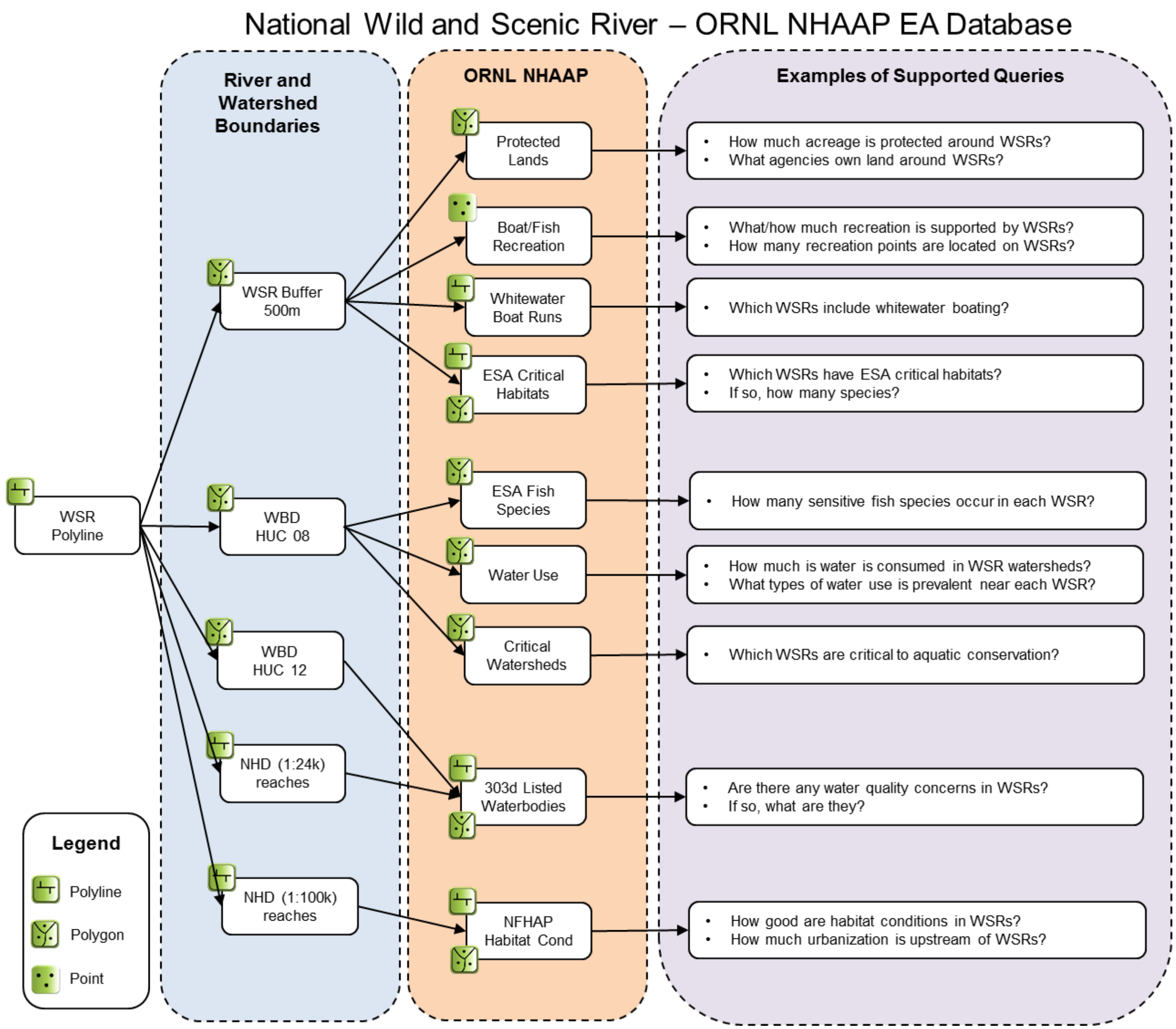

Fig. 4. Depiction of database spatially connecting WSRs to ORNL NHAAP environmental data.

3.2 RESULTS

A brief sample of queries developed using the WSR-NHD database is provided. The percentage of protected lands falling within a 500 m buffer around WSR-NHD river segments varies from less than 1% (Wolf River, WI) to 100% (12 rivers) (Table 2). The number of different entities owning protected lands around WSR-NHD river segments ranges from 1 to 12 (Table 2); the amount of acreage that is owned by various entities or unprotected also varies dramatically. For example, though nine different entities own protected lands adjacent to the Eel River in California, most of the area adjacent to the river remains unprotected (Fig. 5). In contrast, only two entities, NPS and USFS, own 100% of lands adjacent to the Kings River in California (Table 2).

Other queries produced interesting and varied results for WSRs (Table 3). Population density differs widely, from <1 individual per km^2 along several Alaskan rivers to >290 individuals per km^2 along highly populated river areas (e.g. Loxahatchee River, FL). Water use also is highly variable, ranging from <1 L per km^2 per day (primarily Alaskan rivers) to >20,000 L per km^2 per day in the Little Beaver River watershed in Ohio (Table 3). However, note that estimates of both population density and water use are derived from averages for the HUC08 subbasin in which each WSR is located. Thus these are not accurate estimates of population density adjacent to each river bank or of water use specifically from each river. However, most WSRs are moderate-to-large river systems spanning from one to multiple HUC08 subbasins. Thus HUC08 subbasins provide an adequate measure of environmental context to provide a relative comparison among WSRs.

For other environmental variables, a 500 m buffer or NHD catchments were used to assign values to each WSR. Approximately 55% of all WSRs had mainstem or tributary reaches designated as impaired under the EPA 303d waterbody listing (Table 3). Disturbance along at least part of the drainage of 13 of the 49 WSRs (26%) was classified as “high,” according to the National Fish Habitat Action Plan habitat disturbance summary. Endangered Species Act–designated critical habitats for listed endangered and threatened species were found in 28% of WSRs. Boat ramp and fishing access locations were also abundant, occurring at 55% of WSRs (Table 3). Finally, according to data from the National Whitewater Inventory (AW 2013), most WSRs (61%) provide some form of whitewater boating recreation (Table 3).

Table 2. Summary of protected lands and primary (majority), second, and third largest land-owning entity within a 500 m buffered acreage around each WSR

WSID	River name	Buffered acreage	Protected acreage	% Protected	# Entities	Majority	Second	Third
ALAG1	Alaganack River, AK	25,615	25,615	100	5	NPS	Private	BLM
ALAT1	Alatna River, AK	33,123	33,123	100	2	NPS	Private	---
ALLA1	Allagash River, ME	43,747	19,069	44	3	None	State	Unknown
ANIA1	Aniakchak River, AK	26,730	26,730	100	2	NPS	NOAA	---
BLD1	Big and Little Darby Creeks, OH	31,330	3,150	10	4	None	County	Private
BLSTN1	Bluestone River, WV	7,724	7,217	93	4	NPS	State	DOD
CLP1	Cache le Poudre River, CO	32,975	29,809	90	8	USFS	NPS	None
CHAR1	Charley River, AK	87,541	87,532	100	1	NPS	---	---
CHIL1	Chilikadrontna River, AK	7,941	7,941	100	2	NPS	State	---
CSL1	Cossatot River, AR	13,196	10,491	80	3	USFS	Unknown	State
EEL1	Eel River, CA	176,858	54,366	31	9	None	USFS	State park
8M1	Eight Mile River, CT	8,839	3,731	42	9	None	Private	Unknown
FARM1	Farmington River, CT	5,598	1,563	28	4	None	State	DOD
FLTH1	Flathead River, MT	74,047	69,913	94	6	USFS	NPS	BOR
GREG1	Great Egg Harbor River, NJ	27,645	14,196	51	6	None	State	NOAA
JOHN1	John River, AK	25,114	25,114	100	3	NPS	State	Private
KERN1	Kern River, CA	48,410	47,467	98	3	USFS	NPS	None
KING1	Kings River, CA	34,265	34,262	100	2	NPS	USFS	---
KLAM1	Klamath River, CA	74,774	56,380	75	7	USFS	None	NAM
KOBU1	Kobuk River, AK	41,759	41,759	100	3	NPS	Private	State
LAMP1	Lamprey River, NH	7,885	1,777	23	7	None	Unknown	State
LIBE1	Little Beaver River, OH	21,427	3,127	15	1	None	State	---
LIMI1	Little Miami River, OH	35,663	3,265	9	4	None	State	County
LOXA1	Loxahatchee River, FL	5,000	4,540	91	6	State	State	None
LUMB1	Lumber River, NC	23,286	4,276	18	3	None	State Park	Private

Table 2. Summary of protected lands and primary (majority), second, and third largest land-owning entity within a 500 m buffered acreage around each WSR (continued)

WSID	River name	Buffered acreage	Protected acreage	% Protected	# Entities	Majority	Second	Third
MAUR1	Maurice River, NJ	9,758	4,170	43	7	None	State	TNC
MERC1	Merced River, CA	48,462	47,605	98	8	NPS	USFS	BLM
MISS1	Missouri River, NB & SD	50,858	41,919	82	8	NPS	None	Private
MULC1	Mulchatna River, AK	9,732	9,732	100	2	NPS	State	None
MUSC1	Musconetcong River, NJ	10,164	6,405	63	6	None	Unknown	State
NR1	New River, NC	9,613	1,723	18	2	None	State park	Private
NFKO1	North Fork Koyuku River, AK	44,145	44,145	100	4	NPS	Private	Unknown
OB1	Obed River, TN	16,156	11,760	73	2	State	NPS	None
RIGR1	Rio Grande River, NM	32,366	28,570	88	5	BLM	None	USFS
SALM1	Salmon River, AK	28,926	28,926	100	2	NPS	Private	---
SMIT1	Smith River, CA	47,435	40,074	84	5	USFS	None	State park
SNAK1	Snake River Headwaters, WY	146,132	140,912	96	7	USFS	NPS	None
STCR1	St Croix River, MN & WI	138,148	124,254	90	12	NPS	Private	None
SAC1	SudburyAssabetConcord River, MA	11,507	4,473	39	12	None	FWS	City
TAUN1	Taunton River, MA	14,726	4,828	33	9	None	NOAA	State
TINA1	Tinayguk River, AK	20,338	20,338	100	1	NPS	---	---
TRIN1	Trinity River, CA	90,268	70,375	78	6	USFS	None	NAM
TUOL1	Tuolomne River, CA	29,014	24,643	85	5	NPS	USFS	None
VERM1	Vermillion River, IL	6,151	4,204	68	3	State	None	Private
VIRG1	Virgin River, UT	57,812	55,117	95	5	NPS	BLM	None
WEKI1	Wekiva River, FL	16,401	12,443	76	5	State	None	L.Gov.
WEST1	Westfield River, MA	31,984	10,482	33	5	None	State park	State
WHIT1	White Clay Creek, DE & PA	60,585	12,950	21	8	None	State park	Unknown
WOLF1	Wolf River, WI	9,087	34	< 1	2	None	State	Private

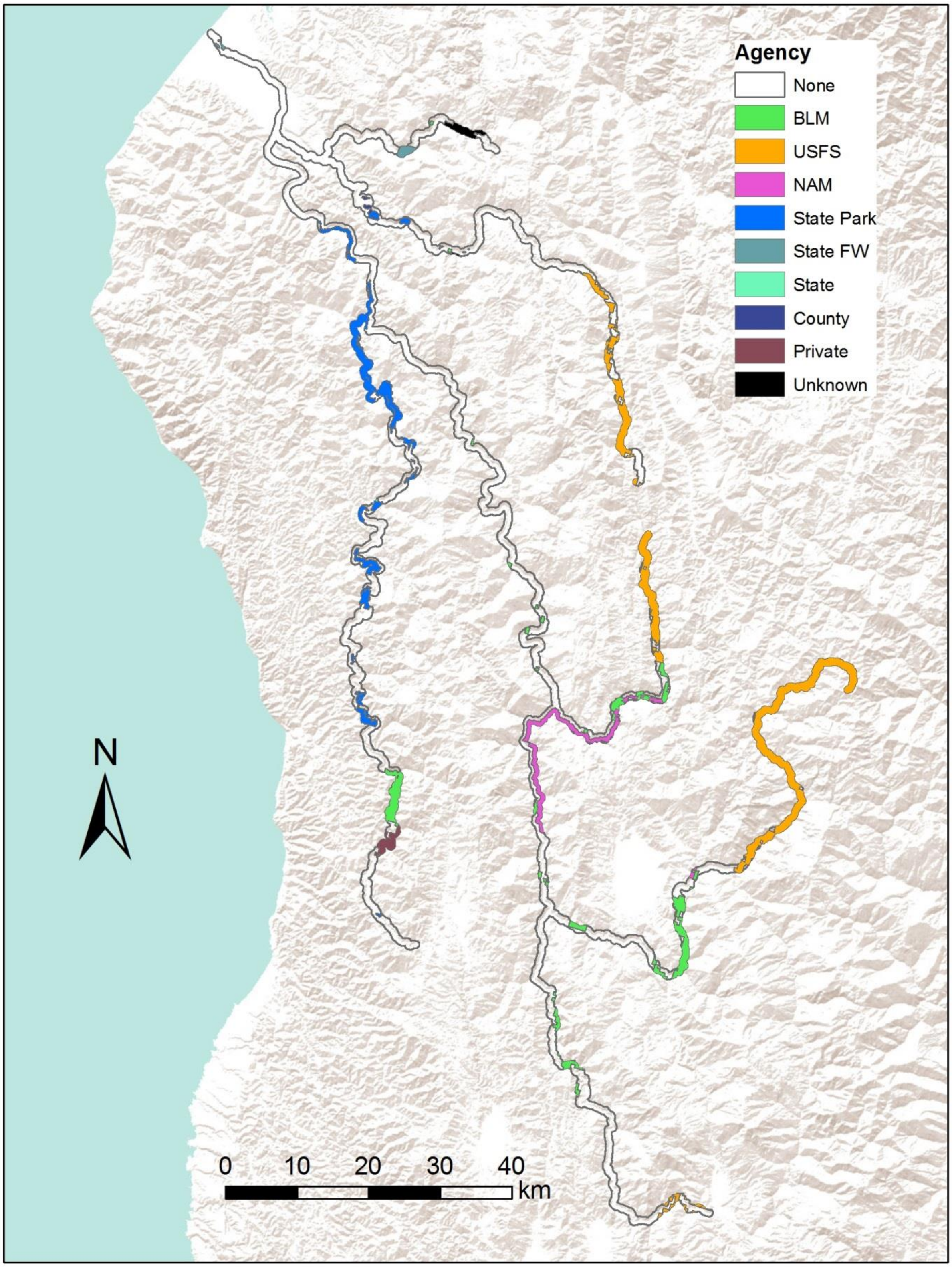

Fig. 5. Eel WSR and adjacent protected lands owned by various agencies falling within a 500 m buffer.

Table 3. Summary of a sample of queries produced using National Wild and Scenic River ORNL-NHAAP environmental attribution database The term “303d” refers to the EPA 303d waterbody listing under the Clean Water Act. “Boat,” “Fish,” and “WW” refer to boat ramps, fishing access points, and whitewater, respectively. “Yes” indicates the presence of various attributes; a blank indicates they were not detected

WSID	Population density (ind/km^2)	Water use (L/day/km^2)	303d list	NFHAP disturbance	# Critical habitats	# Boat and fish	WW boating
ALAG1	<1	1		V. Low–Low			
ALAT1	<1	<1		V. Low			Yes
ALLA1	6	64		V. Low	1	7 , 1	Yes
ANIA1	<1	2		V. Low			Yes
BLD1	105	1408	Yes	Mod.–High			
BLSTN1	<1	2934	Yes	Mod.		3 , 0	Yes
CLP1	32	2692		Low	1	1 , 3	Yes
CHAR1	2	37		Low			Yes
CHIL1	<1	<1		V. Low			Yes
CSL1	10	145		Mod.			Yes
EEL1	11	437	Yes	Low	6	0 , 3	Yes
8M1	290	3805	Yes	Mod.		0 , 1	
FARM1	255	2127	Yes	Low			Yes
FLAT1	6	515		V. Low–Mod.	2	0 , 3	Yes
GREG1	212	1299	Yes	Mod.		0 , 1	
JOHN1	<1	<1		Low			
KERN1	36	6762		V. Low		0 , 1	Yes
KING1	30	5122		V. Low–Low			Yes
KLAM1	6	589	Yes	V. Low–High	4	2 , 1	Yes
KOBU1	<1	3		V. Low			
LAMP1	111	937	Yes	Low			
LIBE1	176	20157	Yes	High		0 , 1	Yes
LIMI1	120	6263	Yes	Mod.–High		2 , 1	Yes
LOXA1	292	3974		Low	1	1 , 0	
LUMB1	42	535	Yes	Mod.		3 , 0	
MAUR1	125	1492	Yes	Mod.		1 , 2	
MERC1	26	4724		V. Low–Low			Yes
MISS1	5	667	Yes	Mod.–High	1	11 , 5	
MULC1	<1	<1		V. Low			
MUSC1	244	6928	Yes	V. High		0 , 1	Yes
NR1	30	276	Yes	High		2 , 1	Yes
NFKO1	<1	<1		Low			
OB1	23	2886	Yes	Low	2		Yes
RIGR1	6	2683	Yes	Low	1	0 , 2	Yes

Table 3. Summary of a sample of queries produced using National Wild and Scenic River ORNL-NHAAP environmental attribution database (continued)

WSID	Population density (ind/km^2)	Water use (L/day/km^2)	303d list	NFHAP disturbance	# Critical habitats	# Boat and fish	WW boating
SAML1	<1	2		V. Low			Yes
SMIT1	8	264		V. Low–Low	4	1 , 1	Yes
SNAK1	4	1390		V. Low	1	4 , 4	Yes
STCR1	102	2304	Yes	V. Low–High		61 , 2	Yes
SAC1	382	2039	Yes	Low–High			
TAUN1	403	1629	Yes	High		1 , 0	
TINA1	<1	<1		Low			
TRIN1	6	569	Yes	V. Low–Low	4	1 , 2	Yes
TUOL1	19	2426	Yes	Low		1 , 0	Yes
VERM1	41	1002	Yes	High		9 , 0	
VIRG1	11	514	Yes	Low	1		Yes
WEKI1	178	1966	Yes	High	1		
WEST1	131	2141	Yes	V. Low–Low		0 , 1	Yes
WHIT1	207	5537	Yes	V. High		0 , 3	
WOLF1	6	490		Low			Yes

4. DISCUSSION

This report provides a methodology for accurately mapping WSRs to support geospatial analyses. The digital mapping of WSRs was followed by an environmental characterization of each river system to determine whether consistent environmental patterns were evident for WSRs across the nation. The spatial scale of hydrography datasets and adherence to written policy descriptions are both critical to accurately mapping WSR resources. Although policy descriptions were sufficient to demarcate the upstream and downstream extent of many rivers, other descriptions rendered interpretation difficult. This issue suggests potential losses in the accurate spatial representation of each waterbody. In addition, the total river mileage reported as protected under WSRs is influenced by the underlying hydrography dataset and interpretation used to determine the extent of protection. The environmental characterization provided information to deduce generalized trends in the uniqueness or commonness of environmental qualities in WSRs. It is interesting that watersheds containing WSRs represent a large range of landscape conditions, from pristine areas to highly modified landscapes. For example, 303d listed waterbodies were prevalent, riparian zones had inconsistent protection, and population size and water use were, at times, very high. However, 28% of WSRs contained critical habitats and almost 80% were documented as supporting some type of aquatic recreation. Altogether, these data suggest that despite inconsistencies in the status of surrounding landscapes, WSRs provide habitats important to aquatic organisms and recreational opportunities important to humans. However, note also that much of the ecological uniqueness and aesthetic importance of WSRs is not captured in this analysis.

The research findings suggest a need for accurate mapping of WSRs for public use. However, results also suggest that methodologies for mapping WSRs should also be consistent. Besides the NPS, the USFS, FWS, and BLM have jurisdiction over WSRs. Since different agencies are responsible for mapping their own assets, the potential exists for large discrepancies in the resultant national layer. Different underlying hydrographic layers, projections, and interpretations could result in large disparities in spatial representation in the final result. Another complication is that multiple agencies may be responsible for a single river. The spatial representation of layers extends beyond just mapping exercises. Federal, state, and local governments rely on accurate spatial representations in planning for development before on-the-ground visits. Geospatial applications are required to provide relatively accurate estimates of renewable and sustainable energy development at the scale of the entire United States to support federal policy. As much as 20% of energy capacity from new potential hydropower development in the conterminous United States could overlap with WSRs (ORNL 2013). However, this estimate was based upon the prevailing geospatial coverage of WSRs created using the 1:2M scale USGS hydrography layer. Therefore, analyses examining areas of potential development require data layers with precise spatial representation and high spatial accuracy.

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